



Capability Demonstrations for Penetrant Nondestructive Evaluation (NDE) of Metallic Tanks and Composite Overwrapped Pressure Vessel (COPV) Liners

As the desired crack detection size is decreased and approaches the physical limitations of liquid penetrant inspection techniques, the approach of performing a probability of detection (POD) validation test at a single aspect ratio, and then extending the results to other aspect ratios based on equivalent area predictions may not be valid. POD testing for penetrant inspection of metallic pressure vessels and COPV liners should be performed at the bounds of the required range of crack aspect ratios.

Applicability

Penetrant NDE of metallic aerospace pressure vessels and COPV liners.

Background

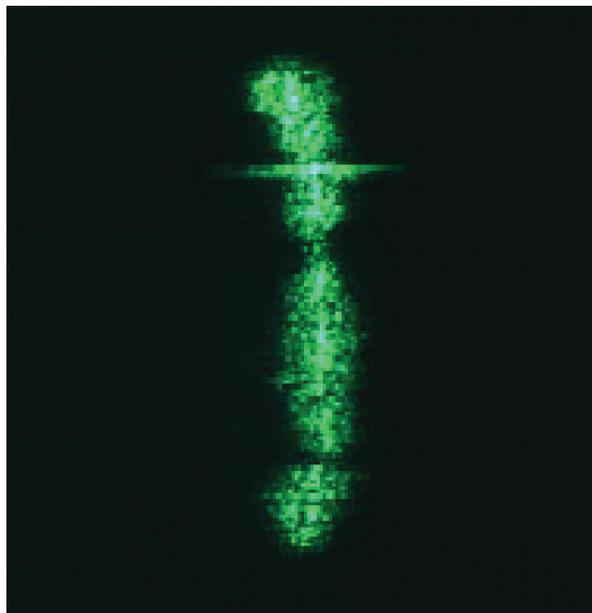
To minimize mass, designers of aerospace systems are reducing the wall thickness for metallic pressure vessels, such as the Mars Science Laboratory (MSL) propellant tank and COPV liners that will be used in future Constellation Program vehicles. This reduction in wall thickness produces higher net section stresses, for a given internal pressure, resulting in smaller critical initial flaw size (CIFS). These smaller crack sizes are approaching the limitations of penetrant NDE. Failure to adequately demonstrate the capabilities of penetrant inspection methods over the required range of crack aspect ratios may lead to the failure to detect a critical flaw resulting in a catastrophic tank failure.

Data and Analysis

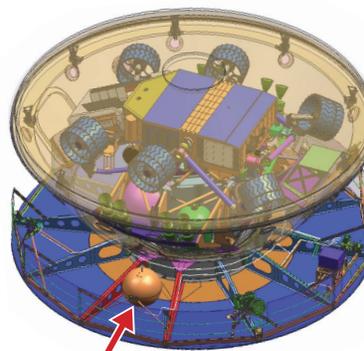
The current standards governing aerospace metallic pressure vessels (AIAA S-080) and COPV liners (AIAA S-081) require that fracture analysis be performed to determine the CIFS for cracks having an aspect ratio ranging from 0.1 to 0.5. They further require that NDE methods have a demonstrated capability of 90 percent probability of detection with a 95 percent confidence (90/95 POD) for the CIFS determined by this analysis. Previously, NASA demonstrated this capability by testing at only a single aspect ratio and then used an equivalent area approach to extend the results to the required range of aspect ratios. However, there is insufficient data to support this approach and it may break down for smaller CIFS. Testing is needed to demonstrate the capability of penetrant inspection for smaller CIFS over the full aspect ratio range, or it may be necessary to demonstrate and implement alternative inspection techniques.

References

AIAA S-080 - Space Systems Metallic Pressure Vessels, Pressurized Structures, and Pressure Components; AIAA S-081 - Space Systems Composite Overwrapped Pressure Vessels (COPVs); NASA-STD-5009 - Nondestructive Evaluation Requirements for Fracture-Critical Metallic Components; Orbiter Fracture Control Program



Penetrant Indication for Tightly Closed (0.088 inch) Fatigue Crack



MSL Cruise Stage Propellant Tank

